

Lightning NO_x Production and Its Consequences for Tropospheric Chemistry

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Cloud-resolving case-study simulations of convective transport and lightning NO production have yielded results which are directly applicable to the design of lightning parameterizations for global chemical transport models. In this work we have used cloud-resolving models (the Goddard Cumulus Ensemble Model (GCE) and MM5) to drive an off-line cloud-scale chemical transport model (CSCTM). The CSCTM, in conjunction with aircraft measurements of NO_x in thunderstorms and ground-based lightning observations, has been used to constrain the amount of NO produced per flash. Cloud and chemistry simulations for several case studies of storms in different environments will be presented. Observed lightning flash rates have been incorporated into the CSCTM, and several scenarios of NO production per intracloud (IC) and per cloud-to-ground (CG) flash have been tested for each storm. The resulting NO_x mixing ratios are compared with aircraft measurements taken within the storm (typically the anvil region) to determine the most likely NO production scenario. The range of values of NO production per flash (or per meter of lightning channel length) that have been deduced from the model will be shown and compared with values of production in the literature that have been deduced from observed NO spikes and from anvil flux calculations. Results show that on a per flash basis, IC flashes are nearly as productive of NO as CG flashes. This result simplifies the lightning parameterization for global models (ie., an algorithm for estimating the IC/CG ratio is not necessary). Vertical profiles of lightning NO_x mass at the end of the 3-D storm simulations have been summarized to yield suggested profiles for use in global models. Estimates of mean NO production per flash vary by a factor of three from one simulated storm to another. When combined with the global flash rate of 44 flashes per second from NASA's Optical Transient Detector (OTD) measurements, these estimates and the results from other techniques yield global NO production rates of 2-9 TgN/year. Simulations of the photochemistry over the 24 hours following a storm has been performed to determine the additional ozone production which can be attributed to lightning NO. Convective transport of HO_x precursors leads to the generation of a HO_x plume which substantially aids the downstream ozone production.